WILLIAM RAMSAY

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IN that elegant tribute to Ramsay, written in the days when comradeship between the scientists of England and Germany was close, Ostwald summarizes him as one belonging to the romantic type in science. Romantic he was, for his imagination was unlimited. The secret of Ramsay's great triumphs lay in the fact that with this imagination there was a well-balanced knowledge of the science, with a seer's insight into the significance of its laws. Bold in the conception of a problem, he was brilliant beyond comparison in its execution. With no fetish to hold him, with the mantle of the prophet about him, and with amazing manipulative skill, he laid bare, in rapid succession, a regular little battalion of new gases in the atmosphere, followed by transmutation experiments which made the scientific world gasp and hold its breath in expectancy of the next dare-devil leap.

This genius, born in Glasgow in 1852, did not spring from any geniuses, but, like many another man of talent, his stock was of a fairly ordinary type. To be sure, there was an uncle with a reputation as a geologist, and the father had some scientific tastes, but nothing at all to warrant such outpourings in the offspring. When eleven years old he joined the Third Latin Class of the Glasgow Academy, and during the three succeeding years at the institution he did little Latin, gained no prizes, and did much dreaming. Ramsay describes himself in a short autobiography as "to a certain extent precocious, though idle and dreamy youngster." This fits in with Ostwald's theory of the genius: "The precociousness is a practically universal phenomenon of incipient genius, and the dreamy quality indicates that original production of thought which lies at the basis of all creative activity." Even thus early he evinced a passion for languages, for it is recorded that during sermon time at church he read the French and German texts of the Bible and translated them into English. In after years, as president of an international scientific gathering, he would astound the assembly by addressing them successively in French, German and Italian.

His introduction to chemistry came in quite an unexpected way. A football skirmish resulted in his breaking a leg, and to lessen the monotony of convalescence, Ramsay read Graham's "Chemistry," with the object, as he frankly confesses, of learning how to make fireworks. During the next four years his bedroom was full of bottles and test-tubes, and often full of strange odors and of startling noises. But systematic chemistry was not taken up till 1869, three years after he had entered the University of Glasgow. Then, it seems, the passion came on, and with it, a passion for the cognate science, physics. This resulted in an introduction to William Thompson (later Lord Kelvin), the then professor, who set the youngster upon the elevating task of getting the "kinks" out of a bundle of copper wire, an operation which lasted a week. It is to be presumed that Thompson was favorably impressed with the manner in which this piece of research was carried out, for Ramsay was immediately introduced to a quadrant electrometer and asked to study its construction and use.

A year's introductory study of chemistry decided Ramsay upon his career, and with his parents' blessing he set out for Heidelberg in 1870, to be exchanged for Tübingen some months later. In Tübingen ruled Fittig, whose lectures were "distinct and clear," whose scholarship was sound, and whose research was methodical. The two years spent at Tübingen were full of work and no play. "I was up this morning," he writes to his father "at 5.30 and studied and took my breakfast from 6 to 7,—a class from 7 to 8, one from 8 to 9, and 9 to 3 laboratory (I lunch now to have more time for work, and don't dine till 6), and from 3 to 5 I studied, then from 5 to 6 lecture, and then I dined. And now at 8 I must start again." And so this was kept up—all the time, curiously enough, with emphasis on organic chemistry, a branch of the science which Ramsay almost wholly abandoned in his later and most productive years—till the time for the Ph.D. examination. "On Monday at 7 it began and lasted till half-past 12; then in the afternoon from 3 to 8, so we had a good spell of it." The questions in chemistry were: (*a*) the resemblances and differences between the compounds of carbon and silicon, and (*b*) the relation between glycerine and its newer derivatives and the other compounds containing three atoms of carbon; in physics: (*a*) the different methods for determining the specific gravity of gases and vapors, and (*b*) the phenomena which may be observed in crystals in polarized light.

I managed to answer the first perfectly, the second, however, not so well, and the two questions in physics pretty well. Then to-night we had the oral exam. The five professors who compose the faculty were there. Fittig gave some very difficult questions. Reusch (physics), on the other hand, very easy ones. . . . We had to dress up and put on white kids, and I had to get a "tile" especially for the occasion. Then we were sent out after the exam. for about five minutes and were then called in and formally told we had passed.

A dissertation on "toluic and nitrotoluic acids," which gave no glimpse of the future before him, completed Ramsay's Ph.D. requirements, and he returned to Glasgow, where he became assistant in the Young Laboratory of Technical Chemistry. And now Ramsay had to turn his attention from organic to inorganic chemistry, for most of the courses at the technical school were devoted to the latter. Though the physico-chemistry background was entirely lacking, and therefore the knowledge obtained could hardly have been more than miscellaneous, innumerable facts were picked up and stored for future reference. An opening as tutorial assistant at Glasgow University offered the possibilities of a more congenial academic atmosphere, and also the hope of continuing his interrupted research in organic chemistry.

The cellars of the University Laboratory contained a large collection of fractions of "Dippel-Oil" prepared by Professor Thomas Anderson. These were regarded by Ferguson (his successor), whose interest in Chemistry was almost entirely that of an antiquary, more or less in the light of museum specimens, and he was horrified when Ramsay suggested that he should be allowed to "investigate" them, but he eventually gave way to Ramsay's importunity. The result was a very substantial addition to our knowledge of the pyridine bases and their derivatives.[2]

The chemistry of dyes and explosives was not to be his life work. How he turned from this to the more mathematical branch of the subject is ascribed by Ramsay himself to problems he encountered in attempts to determine the molecular weights of some of his organic compounds by the Victor Meyer vapor density method. But we must also add that Ramsay, with that instinct for detecting the truly important among a mass of new theories and facts, which was one of his greatest assets, early foresaw the part the new science of physical chemistry would play in the development of chemistry. Thus he was one of the earliest in England to appreciate the true significance of Guldberg and Waage's "law of mass action," just as, at a later date, he was among the first to seize upon and translate Van't Hoff's celebrated paper on the analogy between

[2] "Sir James Dobbie" (68), p. 48.

the state of substance in solution and the same when in a state of gas. The Victor Meyer method suggested to him experiments on the volume of liquids at their boiling point, and this in turn gave rise to a whole series of new possibilities, the experimental side of which kept him and his collaborators, particularly Young and Shields, busy even after he had settled in University College years later.[3]

For six years Ramsay remained assistant at Glasgow University, and though during that time he had been a candidate for several chairs and lectureships, nothing came of any of them. So discouraged did he become that there was much discussion in the family as to the advisability of starting business as a chemical manufacturer. But before this scheme could be put into execution a vacancy at University College, Bristol, presented itself. The story goes that his knowledge of Dutch saved the day. According to this account one of the members of the university council, a minister, was much perplexed with a Dutch text in his possession, and Ramsay volunteered a translation. The result was Ramsay's appointment by a majority of one. The stipend was fixed at a minimum of £400 ($2,000) per year. The contract read:

> The professor will be required to give three lectures per week for the first two terms, say 60 lectures, together with class instruction in connection therewith . . . and a short course of lectures in the third term. He will also be required to superintend the laboratory during the whole session, and to give evening lectures once a week during the first two terms, together with class instruction in connection therewith. . . . The scheme of the college contemplates the possibility of occasional lectures being delivered in neighboring towns by the Professor or his assistant. . . . In connection with the Cloth working Industry, special instruction in dyeing, etc., may be required under an arrangement not yet concluded with the worshipful the Cloth-workers' Company of London.

The professor, not yet turned thirty, was to be kept busy on the job, with very little opportunity for research—an altogether minor consideration to the worthy councillors. But they had not reckoned on Ramsay's energy and capacity. Determinations of the density of gases, of the specific volumes of liquids at their boiling point, of the vapor pressures and critical constants of liquids were soon in full blast. And then came those

[3] It was while blowing the bulbs used in this research (the volumes of liquids at their boiling point), I believe, that he first became aware of the asset he possessed for physical work in his skill as a glass-blower. He had learnt the art at Tübingen, although it was only in his later researches that his marvellous manipulative power was fully developed.—Sir James Dobbie.

classical determinations on the thermal properties of solids and liquids, and on evaporation and dissociation, most of which was done with his assistant, Young, which continued at full blast for the next five years until Ramsay's transfer to London. This appointment came in 1887. By that time Ramsay's reputation was such that the following year he was elected an F.R.S. (Fellow of the Royal Society).

In London his physico-chemical researches were further extended. Among these particular mention should be made of perhaps the most brilliant of them all—the measurement of surface tension up to the critical temperature, which led to the well-known law supplying us with a method for determining the molecular weight of liquids. Here Ramsay had an able assistant in Shields.

In 1890 the British Association met at Leeds, and two of the great continental founders of modern physical chemistry, Van't Hoff and Ostwald, were present. Ramsay, who represented the school in England, naturally took a keen interest in this meeting.

> Ramsay and Ostwald met for the first time as fellow-guests in my house, which became accordingly a sort of cyclonic center of the polemical storm that raged during the whole week. . . . The discussion was incessant. . . . I remember conducting a party to Fountains Abbey on the Saturday and hearing nothing but talk of the ionic theory amid the beauties of Studley Royal. The climax, however, was reached the next day, Sunday. The discussion began at luncheon when Fitzgerald raised the question of the molecular integrity of the salt in the soup and walked round the table with a diagram to confound Van't Hoff and Ostwald. . . . Ramsay was no silent spectator. Being a convinced ionist, he was eager in helping out the expositions of Ostwald, whose English at that time was imperfect and explosive, and his wit and humor played over the whole proceedings. . . . It was the beginning of relations of great mutual sympathy and regard between Ramsay and Ostwald, which lasted till they were divided by their respective national sympathies at the unhappy outbreak of war.[4]

And now we come to a momentous event in the career of our hero. Lord Raleigh had for some time been engaged in determinations of the exact densities of a number of gases. Among these was nitrogen. In his experiments Raleigh found that the density of nitrogen obtained from the air was slightly but consistently higher than that obtained from artificial sources. Writing to *Nature* (1892) he says:

> I am much puzzled by some results as to the density of nitrogen and shall be obliged if any of your chemical readers can offer suggestions as

[4] Professor Smithells.

to the cause. According to two methods of preparation I obtain quite distinct values. The relative difference, amounting to about 1/1,000th part, is small in itself; but it lies entirely outside the errors of experiment.

The difference in the weights of one liter of the gas obtained in the one case from atmospheric air and in the other from ammonia varied by about 6 in 1,200, or about 0.5 per cent., but the accuracy of the method did not involve an error of more than 0.02 per cent.

With that keen scent for any promising material Ramsay immediately took up the problem. Some years previously he had found that nitrogen is absorbed fairly readily by magnesium. This suggested to him that by first getting rid of the oxygen in the air, and passing the remaining nitrogen repeatedly over heated magnesium, any other gas that might possibly be present in the atmosphere would remain unabsorbed. This unabsorbed gas was isolated and found to give a characteristic spectrum. The name *argon* was given to the newly discovered ingredient of the atmosphere. It proved to be more refractory than the comparatively inert nitrogen: it just simply would not make friends and combine with any other element!

Shortly after this Ramsay's attention was called to some experiments of Hillebrand, of the U. S. Geological Survey, in which he obtained a gas believed to be nitrogen from certain minerals, particularly one called clevite, but which was now suspected to contain argon as well. Ramsay lost no time. From it he obtained argon, to be sure, but also another gas, with a spectrum all its own, which showed it to be identical with an element present in the chromosphere of the sun, and which until then had been considered peculiar to the sun. Lockyer years ago gave the name "helium" to it, and now Ramsay had rediscovered it on mother earth. But let the discoverer tell the exciting news. On the 24th of March, 1895, he writes to his wife:[5]

Let's take the biggest piece of news first. I bottled the new gas in a vacuum tube, and arranged so that I could see its spectrum and that of argon in the same spectroscope at the same time. There is argon in the gas; but there was a magnificent yellow line, brilliantly bright, not coin-

[5] Ramsay married Margaret, daughter of George Stevenson Buchanan, in August, 1881, soon after he had been appointed principal of Bristol College—a position he attained one year after his arrival in Bristol. This union proved a particularly happy one. "To have such a helpmate as my wife has brought me happiness which I must acknowledge with the greatest thankfulness." And at a later date he wrote to a friend: "You have got a good son and daughter and that is much to rejoice at. So have I."

cident with but very close to the sodium yellow line. I was puzzled, but began to smell a rat. I told Crookes,[6] and on Saturday morning when Harley, Shields,[7] and I were looking at the spectrum in the dark room a telegram came from Crookes. He had sent a copy here[8] and I enclose that copy. You may wonder what it means. Helium is the name given to a line in the solar spectrum, known to belong to an element, but that element has hitherto been unknown on earth. . . . It is quite overwhelming and beats argon. I telegraphed to Berthelot[9] at once yesterday—"Gaz obtenu par moi clevite mélange argon helium. Crookes identifie spectre. Faites communication Académie lundi.—Ramsay." . . . I have written Lord Rayleigh and I'll send a note to the R.S. (Royal Society) to-morrow. . . .

The first public account of helium was given to a semi-bewildered audience at the annual meeting of the Chemical Society, 1895, on the occasion of the presentation of the Faraday medal to Lord Raleigh. Further investigations proved that helium was not only a terrestrial element, but also occurred in quite a number of minerals and mineral waters. To Kayser, however, was left the proof of its presence in the air. Like argon it simply refused to combine with any other substance.

To the ancients air was a source of investigation, and it had remained so. Till 1894 no one, least of all a scientist,[10] would have suspected the existence in the atmosphere of undiscovered elements. Ramsay and Raleigh's discovery shook the scientific world. Recognition came from all parts. Lord Kelvin, as president of the Royal Society, presented Ramsay with the Davy Medal, with the following comment:

> . . . The researches on which the award of the Davy Medal to Professor Ramsay is chiefly founded are, firstly, those which he has carried on, in conjunction with Lord Raleigh, in the investigation of the properties of argon, and in the discovery of unproved and rapid methods of getting it from the atmosphere; and secondly, the discovery in certain rare minerals, of a new elementary gas which appears to be identical with the hitherto hypothetical solar element, to which Mr. Lockyer many years ago gave the name of "helium." . . . The conferring of the Davy Medal on Professor Ramsay is a crowning act of recognition of his work on argon and helium which has already been recognised as worthy of honor by scientific societies in other countries. For his discoveries of these gases he has already been awarded the Foreign Membership of the Société Philosophique de Genève and of the Leyden Philosophical Society. He has had the Barnard Medal of Columbia College awarded to him by the American Academy of Sciences, and within the last few weeks he has been elected a Foreign Correspondent of the French Académie des Sciences.

[6] Sir William Crookes, the famous physicist.
[7] His two assistants.
[8] 12 Arundel Gardens, their home.
[9] A famous French chemist.
[10] Cavendish, in 1785, did suspect some such possibility.

Such was the excitement aroused by these discoveries that even young students were filled with the epidemic. We are told that "answers to examination questions showed that oxygen as a constituent of our air was almost forgotten in the anxiety on the part of the candidate to show that he or she knew all about argon." But Ramsay had not yet sufficiently dumfounded his scientific confrères. From a careful study of Mendeleeff's periodic grouping of the elements he came to the conclusion that another inert gas ought to exist between helium and argon, employing a process of reasoning quite analogous to one used by the celebrated Russian many years before when, with the help of his periodic table, he predicted the discovery of new elements. Ramsay ransacked every possible source for this new element: minerals from all parts of the globe, mineral waters from Britain, France and Iceland; meteorites from interstellar space—all without result. A clue was at length obtained when he found that by diffusion argon could be separated into a lighter and heavier portion. This suggested the presence of the unknown gas as an impurity in argon. It was evident that the unknown gas, if present, could be there in minute quantities only to have escaped detection. That meant that the larger the quantity of argon employed the better the possibilities of getting appreciable quantities of the unknown constituent.

A simple method of separating the constituents in a mixture of liquids is to boil the mixture, and collect fractions of the condensed vapor. Each constituent will usually go off at a fairly definite temperature. This, in principle, was the method employed by Ramsay and his assistant, Travers. They prepared, to begin with, no less than fifteen liters of *liquid* argon!

> On distilling liquid argon, the first portions of the gas to boil off were found to be lighter than argon; and on allowing the liquid air to boil off slowly, heavier gases came off at last. It was easy to recognise these gases by help of the spectroscope, for the light gas, to which we gave the name *neon* or "the new one," when electrically excited emits a brilliant flame colored light; and one of the heavy gases, which we called *Krypton* or "the hidden one," is characterised by two brilliant lines, one in the yellow and one in the green part of the spectrum. The third gas, named *xenon* or "the stranger" gives out a greenish-blue light, and is remarkable for a very complex spectrum in which blue lines are conspicuous.

A trio, neon, xenon, krypton, added to helium and argon—making five new gases—and all in the atmosphere!

Further recognition came from the Chemical Society of London. They awarded Ramsay the Longstaff medal, given

triennially to the Fellow of the Chemical Society who, in the opinion of the Council, has done the most to promote chemical science by research. "If I may say a word of disparagement," added Mr. Vernon Harcourt, the president, in presenting the medal, "it is,"—and here we can see the twinkle in his eye—"that these elements (argon, helium, etc.) are hardly worthy of the position in which they are placed. If other elements were of the same unsociable character chemistry would not exist."

Ramsay's studies on helium led him to ponder over this question: why is helium only found in minerals which contain uranium and thorium—substances which give rise to radio-active phenomena? Attempts to answer this led him into the field of radio-activity, with results which even surpassed his investigations on the inert gases of the atmosphere. In 1903, in conjunction with Soddy, he succeeded in proving that helium, an element, could be produced from radium, another element. The transmutation of the elements come to life again! Those poor, foolish old alchemists, we were always led to believe, wasted their lives in vain attempts to transmute the baser metals into gold. And here comes the dashing Ramsay, bold, as usual, to audacity, and calmly announces that *his* experiments prove the alchemists not to have been such fools after all! Succeeding experiments on the action of radium salts on copper and lead solutions led Ramsay to believe that copper and lead can undergo disintegration into sodium and lithium, respectively—two entirely different elements! These latter claims still wait to be verified, but there is reasonable hope for assuming that various experimenters throughout the world will soon undertake the task of carefully repeating the entire work, now that peace is once again with us.

A fitting award for these achievements was the bestowal of the Nobel Prize to Ramsay in 1904. The distribution of the prizes took place in Stockholm on December 10 of that year, in the presence of King Oscar and the royal family, foreign ministers and members of the cabinet, and many leading representatives of science, art and literature. After speeches had been delivered by the vice-president and other representatives of the Nobel Committee, and of the academies of science, medicine and literature, King Oscar personally presented Lord Rayleigh (prize winner in physics), Sir William Ramsay[11] (chemistry) and Professor Pavlov (physiology) with their prizes, together

[11] Ramsay had been created a Knight Commander of the Bath (K.C.B.) in 1902, which carried with it the title of "Sir."

with diplomas and gold medals.[12] The distribution of the prizes was followed by a banquet, at which the Crown Prince presided. Count Morner proposed the health of Professor Pavloff, Professor Petterson that of Sir William Ramsay, and Professor Hasselberg that of Lord Rayleigh. The following day Ramsay delivered a lecture on argon and helium at the Academy of Sciences, which was followed by a dinner given in his honor by King Oscar. Writing from Switzerland to a friend some weeks later Ramsay says:

> We had a most gorgeous time for nearly a week, dining with all the celebrities, including old King Oscar. The old gentleman was very kindly and took Lord R. and me into his private room and showed us all his curiosities, the portraits of his sons when they were children and his reliques of Gustavus Adolphus and of Charles XII. The Crown Prince told Mag (his wife) that it was a difficult job to be a king, thereby confirming the Swan of Avon. He said that whatever one supposed a Norwegian would do he invariably did the opposite. Indeed there was nearly a bloodless revolution while we were there; the Prime Minister of Norway was there and I believe the dilemma was only postponed.

Ramsay remained at University College until 1912, when he retired. Two years prior to this, in conjunction with Dr. Gray, he determined the density of the emanation obtained from radium (which Ramsay named "niton") involving the mastery of experimental detail which established him once for all as the great wizard of the laboratory. The total volume of the gas under examination was not much beyond 1/10 cubic millimeter—a bubble which can scarcely be seen. To weigh this amount at all accurately required a balance turning with a load not greater than 1/100,000 milligram. When war broke out Ramsay placed his services at the disposal of the government. Much he could not do. In July, 1915, he writes to a friend that he had had several huge polypi extracted from his left nostril. "I have stood them for years, one gets into the habit of bearing discomforts, but it is a great relief." The relief was to be only temporary. Another operation became necessary in November.

> I was in the surgeon's hands on November 10th and again on the 13th, and he did an operation on my left antrum for a tumor, I believe very successfully. Since then, last Monday, I was irradiated for 24 hrs. with X-rays as a precaution against recurrence. Luckily it is of the kind which can be stopped by Radium. I have had a very bad time.

He died on July 23, 1916. He had lived not a long life but a very fruitful one and a very happy one. Writing to Presi-

[12] The sum of money attached to each prize amounts to about $40,000.

dent Ira Remsen, of Johns Hopkins, a few months before his death Ramsay concludes his letter with:

> Well, I am tired, and must stop. I look back on my long friendship with you[13] as a very happy episode in a very happy life; for my life has been a very happy one.

Ramsay was many-sided. He was an excellent example of the very opposite of Punch's dry-as-dust philosopher. Among musicians[14] and among artists[15] he held his own, for he was an accomplished amateur in both fields. As a linguist he probably has had few equals among scientists. And those of us who, as late as 1912, heard him move a vote of thanks to Professor Gabriel Bertrand, of the Sorbonne, after the latter's lecture to the members of the International Congress of Chemists, will have formed a pretty good picture of his charm and ability as a speaker. Of the many letters that have been preserved, perhaps none sums up so well the characteristics of Ramsay as the following, written to his friend, Dr. Dobbie:

LE HAVRE,
Monday, the Something or other August, 1877.

My dear Dobbie,

Some fool of a Frenchman has stolen all the paper belonging to the French Association, and has left only this half sheet with Le Havre at the top. From the preceding sentence you will have already guessed that the French Ass. is capering around Havre at present, that I form one of the distinguished foreign members, and that all is going as merrily as a marriage bell. Voici 5 jours that I find myself here. I went to Paris with three spirits more wicked than myself, lawyers—a fearful compound 3 lawyers and a chemist—just like NCl_3 for all the world, liable to explode at any moment. . . . I have made the acquaintance with a whole lot of chemists, Dutch and French, and have found an old Dutchman named Gunning ravished to find someone who shares his ideas about *matter*, chemical combination, etc. We excurted yesterday the whole day and talked French and German alternately all the time. When we wanted to be particularly distinct French was all the go. For energy and strong denunciation German came of use. You can't say "Potz-teufel!" in French or "Donnerwetter potztausend sacramento!" An old cove, also a Dutchman, DeVrij, with bowly legs and a visage like this (sketch profile) is also a very nice old boy. The nose is the chief feature of resem-

[13] Dating back to the Tübingen days.

[14] "I spent many evenings at their home, where William (Ramsay) enlivened the company with songs, which in later years were greeted with enthusiastic applause by his students at social evenings of the University College Students' Club. . . . He had a very good voice, played his own accompaniments, and was an expert whistler."—Oho Hehner, a friend.

[15] "Another amusement of Ramsay's was sketching in water colors, an art in which he possessed no inconsiderable share of the talent which belongs to his cousins, Sir Andrew Ramsay's family."—Sir James Dobbie.

blance in the annexed representation. Wurtz and Schukenberger are both Alsations and of course are much more gemüthlich than the echter Französe, but on the whole the fellows I have got to know are very pleasant. Some of the younger lot and I kneipe every evening. Then we bathe every day too in fine stormy water.[16] Eh bien, what is there to say of more? I am going straight back to Glasgow on Wednesday by the special steamer to Glasgow. My money is about done, so I must bolt. . . . By the way I forgot to tell you that I had the cheek to read a communication on picoline, in French, which was received with loud applause. There was some remarks made afterwards very favorable, tho' I say it as shouldn't say it. Adoo. Write to Glasgow and tell me wie geht's.

Yours very Sincerely,

W. RAMSAY.

[16] "He (Ramsay) was a very strong and graceful swimmer and could dive further than any amateur I have seen. When we were in Paris in 1876 the four of us used to go to one of the baths in the Seine every forenoon, and after the first time, when Ramsay was ready to dive, the bathman would pass round the word that the Englishman was going to dive, and everyone in the establishment, including the washerwoman outside, would crowd in and take up positions to watch him. He dived the whole length of the bath and sometimes turned there under water and came back a part of the length."—H. B. Fyfe, a life-long friend.